Conference Reports

THE INVESTIGATION OF FUNDAMENTAL INTERACTIONS WITH COLD NEUTRONS

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The past decade has seen the development of a remarkably fruitful line of experimental inquiry in which beams of low energy neutrons are used for the investigation of fundamental interactions. This work has included studies of parity and time reversal symmetry violation, baryon nonconservation, weak interactions, fundamental constants, charge conservation, and neutron interferometry as well as a variety of other studies. This work has had important implications in particle physics, nuclear physics, astrophysics and cosmology. In the past, the geographical focus of this work has been the High Flux Reactor at the Institut Laue-Langevin (ILL) in Grenoble, France with substantial efforts at other reactors in Germany and the Soviet Union. While researchers from the United States have provided a degree of leadership in this field, a stronger U.S. contribution has been frustrated by the absence of suitable low energy neutron facilities in the U.S.

The proposed National Bureau of Standards Cold Neutron Facility will provide the United States with a world class facility for such investigations. The NBS facility will be unique in the U.S. and it is not likely that a competitive U.S. source will be available within the next decade. The United States and the National Bureau of Standards are therefore presented with the opportunity to provide leadership in an exciting and important area of scientific endeavor.

In order to provide guidance for such a program, the Department of Energy and the National Bureau of Standards sponsored a workshop to review "The Investigation of Fundamental Interactions with Cold Neutrons." This workshop, held at Gaithersburg, 14–15 November 1985, brought together more than 50 leading practitioners in this field from U.S. laboratories and universities as well as from Europe and Canada. A total of 25 talks were given.[1]

In the first talk, N. F. Ramsey (Harvard) reviewed the current status of the experimental knowledge of the properties of the neutron. Following this introduction, J. M. Rowe (NBS) discussed the design plans for the NBS National Cold Neutron Facility and W. Mampe (ILL) described existing facilities at the High Flux Reactor at ILL.

The following session concerned the investigation of the details of neutron β-decay. J. Byrne (Sussex) discussed the theoretical implications of neutron β-decay, both for the theory of weak interactions as well as for astrophysics. It was clear from Byrnes' presentation that an accurate (< 1%) measurement of the mean neutron lifetime, τ_n, would provide an important input into current theories of nucleosynthesis, stellar dynamics and cosmology. Byrne also noted that the uncertainty in τ_n provides a major uncertainty contribution to the theories which predict the solar neutron flux. Following this talk which emphasized the theoretical importance of τ_n, J. Robson (McGill) reviewed the current experimental status and described the na-

[1] G. L. Greene, editor, *The Investigation of Fundamental Interactions with Cold Neutrons*, NBS Special Publications 711 (1986).

ture of the problems which must be faced in any accurate experimental determination of τ_n. Among these problems is the relatively prosaic but, nonetheless technically daunting problem of the absolute determination of a neutron flux. This was reviewed further by D. M. Gilliam (NBS).

There followed a series of talks concerning new experimental efforts to measure τ_n. J. Wilkerson (Los Alamos) described an elaborate electron-proton coincidence counter which, by its large volume, promises very high count rates. Most exciting was his description of a new cryogenic, calorimetric neutron detector which promises to provide a substantial improvement in the accuracy of neutron flux determinations. J. Byrne (Sussex) then described an innovative new technique for measuring τ_n by counting decay protons which have been stored in a Penning trap and subsequently accelerated. This proposal was striking for its careful consideration of systematic effects. D. Dubbers (ILL) and W. Mampe (ILL) then discussed several ongoing experiments at ILL aimed at the determination of τ_n. Perhaps most promising is the effort by W. Paul and associates to trap extremely low energy polarized neutrons in a hexapole magnetic field and observe their population decrease.

The last two talks on the first day of the workshop concerned the details of neutron β-decay and tests of the standard V-A model of the weak interaction. In a very stimulating contribution S. J. Freedman (Argonne) discussed the importance of the measurements of the various polarization and momentum correlation coefficients in neutron β-decay. He also reported very beautiful results from the Heidelberg/ILL/Argonne collaboration measuring the electron asymmetry in polarized neutron decay. Tom Bowles (Los Alamos) then described a new experiment aimed at improving, by at least one order of magnitude, the knowledge of T-violating triple correlation in neutron decay.

The second day's morning session was focussed on studies of parity and time reversal symmetry violation in interactions involving neutrons. E. Adelberger (Univ. of Washington) reviewed the importance of low energy nuclear physics experiments which probe weak interactions by the observation of parity violation. He pointed out that while such experiments are very difficult, they affort a unique window on certain details of the weak interaction P. K. Kabir (Virginia) then reviewed the nature of time reversal symmetry violation and suggested possible experimental tests.

In the following two talks, R. Wilson (Harvard) and B. Heckel (U. of Washington) reviewed existing experimental studies of parity violation and suggested future experimental directions. It seemed clear that the most desirable, and unfortunately the most difficult measurements, involve the interaction of neutrons with very simple nuclei. The simplest of course is the unbound proton in liquid hydrogen targets.

The focus of the workshop then changed from thea investigation of the neutron as a particle to the study of the neutron as a wave. S. Werner (Missouri) reviewed recent experiments involving single crystal neutron interferometry. He was followed by H. Rauch (Vienna) who proposed a variety of ingenious perfect crystal optical devices to manipulate monochromatic neutron beams. A. Zeilinger (Vienna) discussed the prospects for extending neutron optical devices to long wavelengths (>20Å).

In discussing how neutron interferometers might be made more sensitive, R. D. Deslattes (NBS) proposed the construction of multi-lithic interferometers having dimensions approaching 1 meter. Such devices would be extremely difficult to construct and operate. However their realization would represent a tour-deforce in precision engineering. Some of the environmental difficulties in neutron interferometry were discussed by J. Arthur (ORNL).

The remainder of the workshop returned to questions of interest in elementary particle physics. In particular, attention was paid to two experiments which probe the frontiers of current particle theory. M. Baldo-Ceolin (Padua) described the efforts to detect baryon nonconservation in the hypothesized $n-\bar{n}$ reaction. J. M. Pendlebury (Sussex) discussed the search for a nonzero neutron electron dipole moment. It was very gratifying to hear of the enormous improvement in neutron fluxes available at ILL for this important experiment. The workshop closed with reports by R. Golub (Max Planck Institut) and T. Dombeck (Los Alamos) on advanced methods for the production of extremely low energy neutrons.

The proceedings of this workshop have been published.